Remarks

Included herewith is a Request for Continued Examination and the appropriate fee.

Also find attached two articles which further confirm the problematic state of the art as discussed below in section II.

Please recognize the following as an associate attorney in the above identified application:

Kenneth L. Nash Reg. No. 34,399.

Claim Rejections - 35 U.S.C. 112

Claims 75-88 are rejected under 35 U.S.C. 112 as failing to comply with the written description, which requires that one of skill in the art be able to make and use the invention. Specifically, the Examiner objected to Applicant's statement that the sensors are "permanently" mounted. One of skill in the art is well aware that gauges, floats, and the like are often "permanently" mounted to the field equipment for continuous on-site measurements. One of skill in the art would know these sensors are not the same as, for instance, the hand-held measurement equipment carried by service personnel such as voltmeters, power meters, and the like. However, to speed processing, Applicant has deleted the term so the rejection is now moot.

Claim Rejections - 35 U.S.C. 103(a)

Claims 1-7, 9, 12-18, 20-22, 24-35, 35-47, 49-56, 58-63, 61-83 and 85-88 are rejected under 35 U.S.C. 103(a) as being unpatentable over Carmody (US 2002/0143596) in view of Witts et al. (US 4,401,994).

Claim 8 is rejected under 35 U.S.C. 103(a) as being unpatentable over Carmody in view of Witts and further in view of Jurca (US 4,949,263).

Claims 10-11, 19, 23, 36, 48, 57, 64, and 84 are rejected under 35 U.S.C. 103(a) as being unpatentable over Carmody in view of Witts and further in view of Kahleck et al. (US 5,673,190).

I. Previous Arguments by Applicant To Which the Examiner HAS Responded:

1. Applicant argued that Carmody does not teach electronic sensors to monitor operational status or personnel presence. The present Office Action states that Witts "is applied for this feature." (page 20, mid-page)

Clearly Witts does not teach any sensors used for monitoring operational status of a wastewater treatment system or any other system. Witts only monitors entry and exit of employees. Therefore, Applicant now specifies in claim 1 "first sensors" for detecting

operational status of the wastewater treatment systems. Similar requirements were already specified in independent claims 20, 27, 39, 49, 58, 65, and 75. Plainly, neither Carmody nor Witts teach sensors that monitor operational status of a wastewater treatment system.

2. Applicant argued that Witts is nonanalagous art. The Office Action states that Witts' device is reasonably pertinent to the problem of recording the physical presence of service personnel at the monitored location. The Office Action cites *In re Oetiker*, 977 F. 2d 1443, 24 USPQ2d 1443 (Fed. Cir. 1992) for support. (page 24, middle paragraph)

In re Oetiker concerned whether a garment hook for use with a hose clamp is obvious, wherein the Examiner and the Board had argued the garment hook relates to a hooking problem. The Federal Circuit disagreed. "The Board apparently reasoned that all hooking problems are analogous." The Federal Circuit found that a garment hook was nonanalogous art because one of skill in the art of hose clamps would not have been motivated to look at garment hooks.

> We have reminded ourselves and the PTO that it is necessary to consider "the reality of the circumstances", *In re Wood*, 599 F.2d 1032, 1036, 202 USPQ 171, 174 (CCPA 1979)--in other words, **common sense**--in deciding in which fields a person of ordinary skill would reasonably be expected to look for a solution to the problem facing the inventor.... There must be some reason, suggestion, or motivation found in the prior art whereby a person of ordinary skill in the field of the invention would make the combination. That knowledge **cannot come from the applicant's invention itself**. (Emphasis added).

Witts does not teach a system that monitors not only the employee but also the employer who might wish to pocket inspection costs by not sending an employee to perform required maintenance inspections to a large number of different locations on infrequent

occasions for relatively short times. Witts is intended to monitor a large number of employees working for a single employer at a single location. On the other hand, Applicant's device monitors the presence of a single employee at a multitude of different physical locations as per the amended claims (For support of amendments, see e.g., paragraph 0033 of the published application). Neither Carmody nor Witts is even aware of the problem solved by Applicant. Except for Applicant's teachings applied in hindsight, there is no modification to combine these references.

Moreover Witts is completely impractical for use at thousands of homeowner sites. As examples of impracticality for use at homeowner locations, Witts utilizes (1) a motorized time card input that moves the time card into the machine for writing using an impact printer where the printing cannot be interfered with, (2) a magnetic strip reader, (3) three time shift indicators for 24 hour plant operation, (4) three levels of overtime indicators, and (5) a panel that has numerous modes of operation as indicated by various status lights, and other features that are unnecessary, undesirable, and much too expensive for a simple homeowner wastewater treatment system as now specified by Claim 1 and previously specified by claim 49. It does not make common sense to look at the Witts industrial device when trying to provide thousands of homeowner wastewater treatment systems with an inexpensive detector for use where the service personnel are not present but a few times a year and then only for a relatively short time.

The particular problem of concern by Applicant does not involve large numbers of workers in three shifts, with different levels of overtime, wherein magnetic strips are used for some personnel and others require time cards which must be printed while the cards are completely inside the body of the Witts mechanism. Instead, Applicant's system monitors a

multitude of wastewater treatment systems that are often remotely located and seldom visited, and where costs for the monitoring must be kept very small if the homeowners are going to be able to use Applicant's system. Thus, one of skill in the art would not look to devices such as Witts used to track daily flows of personnel working multiple shifts. Accordingly, under *In re Oetiker,* Witts is nonanalogous art.

4. **Applicant argued that the combination of Carmody and Witts is not obvious and that the Examiner improperly used hindsight in making the combination.** The Examiner responded that any judgment on obviousness is in a sense necessarily a reconstruction based upon hindsight reasoning. However, as long as it takes into account only knowledge within the level of ordinary skill at the time of the invention, and does not include information from applicant's disclosure, the reconstruction is proper. The Examiner goes on to note that Witts was issued more than 18 years prior to applicant's invention so that it was well within the level of ordinary skill at the time of the invention. (page 25, last paragraph)

However, the Examiner has not taken into account the level of ordinary skill in the art. Specifically, the Examiner has not responded to Applicant's description of the long standing serious problem of sewage potentially getting into ground water, because experts including regulators could not practically monitor the multitude of wastewater treatment plants and determine whether service providers were actually performing the required maintenance. It is not clear why this longstanding very serious environmental and potentially dangerous problem has existed for decades if the solution was obvious all these years, as the Office Action states in retrospect. (See item II - Previous Arguments to which the Examiner has NOT yet responded).

Neither Witts nor Carmody recognize the problem solved by Applicants. The Office Action does not set forth any instruction in the prior art that would make it obvious for one of skill in the art to combine Witts and Carmody. Assuming arguendo that Witts even works, the combination of Witts and Carmody would not solve the problem of inexpensively monitoring a multitude of physically separate locations. Carmody does not teach or require any telephone data lines to collect personnel information from the personnel detectors as required by the claims. Accordingly, the reconstruction in the Office Action can only be based on Applicant's disclosure. Therefore, the hindsight is improper by law. Applicant respectfully requests reconsideration.

5. **Applicant argued that Carmody does not teach a third party**. The Office Action states it is obvious to modify Carmody to include a third party because it "would advantageously enhance the reliability of the reports." The claims call for "sensors" to do this, which the Office Action admits Carmody does not have. Therefore, it is inaccurate for the Office Action to state that Carmody does have these features or capability as the Office Action presently states. The Office Action goes on to state that the Carmody system is "independent of information received from the plurality of wastewater systems." (page 23, last paragraphs - page 24 first paragraph). This is not true because the Carmody system relies on the statements of the service providers to determine whether services have been completed. Simply combining a third party would not supply any additional information and therefore cannot "advantageously enhance the reliability of the reports."

Applicant again points out that the only "monitoring" by Carmody is based on the

reports from service providers and simple time reminders within Carmody. Carmody has no sensors to provide independent information. The only way a third party would provide any benefit is if the third party is able to monitor the systems independently of the service providers, as taught by Applicant. Witt does not teach a third party who monitors not only the employee but also the employer to provide the information to another third party, i.e., a governmental regulatory agency. Instead, Witt discloses only a monitor for use by the employer and employee's benefit. Accordingly, there is no recognition of the problem solved by Applicant in either Carmody or Witt. Essentially, the Office Action states a third party is obvious, but provides no prior art that even includes all the elements to support this position. Moreover, the Office Action does not point to any teachings in the prior art that would lead one of skill in the art to utilize a third party.

6. **Applicant argued that Jurca is nonanalagous art.** The Office Action states that Jurca teaches an equipment monitoring system that is activated and deactivated at the start and end of a work shift using a mechanical switch. The Office Action again cites *In re Oetiker*, 977 F. 2d 1443, 24 USPQ2d 1443 (Fed. Cir. 1992) for support. (page 24, last paragraph)

It is respectfully submitted that *In re Oetiker* has been misunderstood. In the present case, *In re Oetiker* teaches that the Examiner must present evidence that shows that one of skill in the art of wastewater systems would be motivated to look at the field of vehicle usage recording systems to find a solution for the problem of service companies who do not send service personnel to thousands of remotely located wastewater treatment systems, even though they are paid to do so and claim that they have done so.

> It has not been shown that a person of ordinary skill, seeking to solve a problem of fastening a hose clamp, would reasonably be expected or motivated to look to fasteners for garments. The combination of elements from non-analogous sources, in a manner that reconstructs the applicant's invention only with the benefit of hindsight, is insufficient to present a prima facie case of obviousness.

Just as one of skill in the art of hose clamps would not be expected or motivated to look at garment fasteners, one of skill in the art would not be motivated to look at a system for recording the handling characteristics of fork lifts as a way to solve the problem of service companies who do not send service personnel to great numbers of remotely located wastewater treatment systems. Jurca is clearly nonanalogous art.

7. **Applicant argued that Kahleck is nonanalagous art.** According to the Office Action, Kahleck relates to monitoring of preventive maintenance of equipment. The Office Action again cites *In re Oetiker*, 977 F. 2d 1443, 24 USPQ2d 1443 (Fed. Cir. 1992) for support. (page 25, first paragraph)

Kahleck relates to an office machine management system for controlling printers and photocopy machines, and provides logs with number of copies produced, black and white copies produced, paper jams, and alarm signals. (See abstract). Kahleck sends a signal to say that a service contract should be renewed, **but Kahleck does not have the capability for determining whether it has been renewed or not.** Yet, this is exactly the problem presented. Not only does the Office Action fail to state a motivation for one of skill to look to the field of an office machine management system to solve a problem of dishonest service companies, the Office Action does not provide any teachings that describe the claimed function of "electronically determining of whether a respective contract between one or more owners of said plurality of

wastewater systems and said one or more service companies has been timely renewed."

8. Applicant argued that the Office Action's conclusion of obviousness is based on improper hindsight reasoning. The Office Action states that Witts was issued more than 18 years prior to Applicant's invention and that Applicant's invention merely places a well known device in a specific environment. (page 25, last paragraph)

Neither Witts nor Carmody is aware of or teaches monitoring employers and their employees to provide information to regulators for determining whether service companies improperly collected money for services at thousands of different locations, when the services were not provided. Since the problem is not contemplated in the cited prior art, and no instructions are provided that would make it obvious for one of skill in the art to combine the prior art as proposed, Applicant respectfully believes that improper hindsight reasoning was necessarily used in making the rejection.

Moreover, if the components to solve the problem were known for 18 years, and if the solution was obvious, the Office Action does not explain why the long-standing egregious problem continued to exist during this same18 year time period. Contrary to the Office Action's statements that the solution is obvious, experts in the field who attempted to solve the problem were not successful. *In re Oetiker* goes on to state:

> Oetiker's invention is simple. **Simplicity is not inimical to patentability**. See *Goodyear Tire & Rubber Co. v. Ray-O-Vac Co.*, 321 U.S. 275, 279, 64 S.Ct. 593, 594, 88 L.Ed. 721 (1944) (simplicity of itself does not negate invention); *Panduit Corp. v. Dennison Mfg. Co.*, 810 F.2d 1561, 1572, 1 USPQ2d 1593, 1600 (Fed.Cir.) (the patent system is not foreclosed to those who make simple inventions), cert. denied, 481 U.S. 1052, 107 S.Ct. 2187, 95 L.Ed.2d 843 (1987).

Applicant has provided a great deal of thought to make a system that is simple and

reliable. Perhaps the Examiner is confusing obviousness with simplicity. In fact, perhaps the best inventions are those which are the simplest.

II. Previous Arguments by Applicant To Which the Examiner has NOT Yet Responded:

1. The Examiner has not considered the objective indicia of obviousness - the secondary considerations of the long felt, but unresolved needs and failed attempts to solve the problems. The U.S. Supreme Court and the U.S. Court of Appeals for the Federal Circuit have consistently ruled that such evidence **must** be considered:

> Such "secondary considerations," when present, **must always be considered**. *Stratoflex*, 713 F.2d at 1538. See also *Cable Electric Products, Inc. v. Genmark, Inc.*, 770 F.2d 1015, 1026-28, 226 USPQ 881, 887-88 (Fed.Cir.1985). Such evidence includes commercial success, long felt but unresolved needs, and failed attempts. *Perkin-Elmer Corp. v. Computervision Corp.*, 732 F.2d 888, 895-96, 221 USPQ 669, 675 (Fed.Cir.), cert. denied, --- U.S. ----, 105 S.Ct. 187, 83 L.Ed.2d 120 (1984).

In the present case, regulators have considered aerobic wastewater systems unusable for environmental reasons because they could not trust service personnel to perform the required maintenance at the remote locations, because it was impossible to know if the service had been performed. (See Applicant's Declaration dated October 11, 2004 submitted with the Response filed October 12, 2004 as evidence.) People could not build on their own land due to the problem. The attached article "Aerobic Wastewater Treat," page 2, first paragraph, confirms that aerobic treatment systems are not accepted in all areas due to "concern about improper operation and maintenance by homeowners." See also attached article "Aerobic Residential

Onsite Sewage Systems: An Evaluation of Treated-Effluent Quality," page 18, column 3, first paragraph wherein it will be appreciated that systems have been shown in rigorous testing to work but that maintenance must be provided for the system to work as intended.

It will also be noted from these same articles that the nonprofit organization NSF International has set the standards for aerobic units since 1973. **Applicant's system recently became the only wastewater treatment monitoring system licensed and used by NSF International due to the system's ability to economically verify that maintenance has been performed**. NSF International is recognized as the leading global provider of public health and safety risk management solicitors. With Applicant's invention, regulators can now do their job to protect the environment, and do it at such a very low cost that it is acceptable to require the public to use the system. In some cases, the use of Applicant's system has actually reduced homeowner maintenance costs because the number of required maintenance inspections has been reduced when Applicant's system is used. Moreover, regulators that for many years would not allow aerobic treatment systems are now reconsidering their stance simply because of Applicant's system. Previously regulators could not verify whether proper maintenance had been performed and therefore could not protect environmental health. As discussed in the background to the application, experts have tried for years to solve the problem, but have failed.

Under M.P.E.P. 2141.01, Scope and Content of the Prior art, Section III entitled "Content of the Prior Art Is Determined at the Time the Invention Was Made to Avoid Hindsight", the Examiner is required to ascertain the state of the prior art prior to the invention. Moreover, the law is clear that non-obviousness of a solution is strongly evidenced when experts in the art have tried and failed to solve long standing problems.

In the present case, for well over a decade prior to the present invention, regulators have been highly suspicious and/or aware of routine deceit by services companies whereby money paid by wastewater system owners for routine scheduled inspections is simply pocketed, and no routine inspections are made. In at least one state, the regulators went so far as to prevent use of certain types of wastewater systems - not because the systems do not work properly as long as routine inspections are made, but because the regulators simply do not trust the safety of the environment to the dishonesty and unreliability of service companies. In many cases, this meant that people could not even build on their own land. This is clearly a significant, long-standing problem.

History shows there is evidence of a strong precedent for service companies to falsify routine inspection reports because it provides a quick, easy way to earn inspection money without paying the transportation and manpower costs of sending a service representative to each location. Honest service companies find it difficult to compete in this business environment and may be driven out of business in states where a high percentage of routine inspections are not made and/or are falsified. Carmody and Witt do not recognize this problem and do not provide a practical solution thereto. Applicant's system is the first to provide a solution that successfully works.

This is the scope and content of the prior art as set out by the previously submitted Declaration of Jerry L. McKinney, the present inventor. The Examiner has not questioned any of the above, or even commented, and because the Examiner is required to look at such secondary considerations, Applicant believes that the Examiner concedes agreement with the above assessment of the prior art, and with the assertions of the previously submitted McKinney

Declaration.

Given the longstanding and serious nature of the problem as set forth in the McKinney declaration, and the previous attempts to solve the problem, it is clear that a workable solution was not obvious to those of skill in the art. Accordingly, the rejection to claims based on obviousness is inconsistent with the reality of the situation and experience of experts in the field. Therefore, Applicant respectfully submits that the rejection of the claims based on obviousness is traversed.

2. Applicant previously pointed out that Kahleck does not detect whether a service contract has been renewed or not. Thus, Kahleck cannot anticipate the claims which require this feature. The Examiner did not respond to this argument.

III. New arguments

1 The Office Action states that Jurca teaches a mechanical switch just as Applicant calls for in claim 8.

Unlike Applicant's mechanical switch, Jurca's mechanical switch turns the entire system on and off. Applicant's system has nothing to do with an on-off switch for the entire system. An on-off switch for use in Applicant's system would be impractical because Applicant's system must monitor continuously. It is impermissible to pick and choose from a reference only so much as supports a desired conclusion to the exclusion of other parts of the reference:

> It is impermissible within the framework of section 103 to pick and choose from any one reference only so much of it as will support a given position to the exclusion of other parts necessary to the full appreciation of what such reference fairly suggests to one skilled in the art. *In re Wesslau*, 353 F.2d 238, 241, 147 USPQ 391, 393 (CCPA 1965);

see also *In re Mercer*, 515 F.2d 1161, 1165-66, 185 USPQ 774, 778 (CCPA 1975).

Accordingly, the Jurca switch is entirely unsuitable for use as described in Applicant's claim 8 and would, in fact, prevent operation of Applicant's system except when the service personnel is present.

Summary:

The state of the art at the time of the invention indicates a long standing problem which had not been solved prior to Applicant - facts that support Applicant's invention were not obvious to one of skill in the art at the time of the invention.

Carmody is essentially a paperwork handling system with reminders which can only assume that all paperwork prepared by a service company is accurate. Witts does not perform the claimed function of reporting to parties other than an employer. Moreover, Witts is an extremely expensive and highly impractical system for use in thousands of homeowner sites which include not only mansions, but also trailer houses. Witts is for use by employers to track the time of employees at a single plant and for employees to know the status of their time. Witts provides no teachings to monitor the employer, i.e., the service companies, and report to third parties whether the service companies sent their employees to many different locations. Neither Carmody nor Witts even recognize the problem to be solved. Accordingly, there was no motivation at the time of the invention to combine Carmody with Witts.

It is respectfully submitted that the unrelated patents of Carmody, Witts, Jurca, and Kahleck are deficient and do not show, even in combination, the claim limitations of claims 1-88. Moreover, no motivation has been shown to look to the different fields of Witts, Jurca, or

Kahleck to solve the problem of dishonest service companies who have contracts to perform services at wastewater treatment systems. Therefore, these references are nonanalogous.

For any of the above-listed reasons, it is respectfully submitted that the rejections to claims 1-88 are respectfully traversed and that claims 1-88 are now allowable. Accordingly, Applicant respectfully proposes that the application now stands in condition for allowance and earnestly requests that a Notice of Allowance be issued forthwith.

Respectfully submitted,

C. James Bushman
Reg. No. 24,810

Date: February 7, 2006

BROWNING BUSHMAN P.C.
5718 Westheimer, Suite 1800
Houston, TX 77057-5771
Tel.: (713) 266-5593
Fax: (713) 266-5169

CERTIFICATE OF MAILING

I, Sheri Cooper, hereby certify that this correspondence and all referenced enclosures are being deposited by me with the United States Postal Service as Express Mail with Receipt No. EV317504589 US in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, on February 7, 2006.

By: ______________________
Sheri Cooper

C:\Client\JLM 2002 Trust\14-prelamend-rce.wpd

Aerobic Wastewater Treatment

From ***Pipeline*** *by* ***National Small Flows Clearinghouse,***
*This publication has been adapted for use in Indiana by Purdue University**

Many homes in the U.S. are located in small or rural communities where houses are spaced widely apart. In these communities, central sewerage systems are often not cost-effective, so many homeowners rely on septic systems or other systems that treat and dispose of household wastewater onsite. Some homes for which septic systems are not a good option rely on individual home aerobic systems for wastewater treatment.

Aerobic systems are similar to septic systems in that they both use natural processes to treat wastewater. But unlike septic (anaerobic) treatment, the aerobic treatment process requires oxygen. Aerobic treatment units, therefore, use a mechanism to inject and circulate air inside the treatment tank. This mechanism requires electricity to operate.

For this reason, aerobic systems cost more to operate and need more routine maintenance than most septic systems. However, when properly operated and maintained, aerobic systems can provide a high quality wastewater treatment alternative to septic systems.

Why Choose Aerobic Treatment?

Although there have been home aerobic systems in the U.S. for more than 50 years, their use has been fairly limited. This is due, in part, to the widespread use of septic systems.

Septic tank-soil absorption systems are relatively inexpensive and are easy to maintain. They are the most common onsite wastewater treatment systems used in rural areas. However, there are many households for which a septic system may not be the best wastewater treatment option.

For example, septic systems are not suitable for every lot. In fact, approximately two-thirds of all the land area in the U.S. is estimated to be unsuitable for the installation of septic systems. Some homes may not have enough land area or appropriate soil conditions to accommodate a full sized soil absorption drainfield. In some communities, the water table is too high to allow the drainfield to give adequate treatment to the wastewater before it is returned to the groundwater.

Other site-related concerns include homes located on wooded lots or on lots close to a body of water. Homeowners in wooded areas may not want to clear enough land to install a septic tank and drainfield and the wastewater treated by a septic system is often not of high enough quality to be discharged very close to a body of water.

But one of the most common reasons that aerobic wastewater treatment units are chosen by communities is to replace failing septic systems. Failing septic systems are a major source of groundwater pollution in some areas. If a failed septic system needs to be replaced or if a site is inappropriate for conventional systems, aerobic wastewater treatment becomes a viable option.

Aerobic Wastewater Treatment may be a Good Option when ...

- The soil quality is not appropriate for a septic system
- There is high groundwater or shallow bedrock
- A higher level of wastewater treatment is required
- A septic system has failed
- There is not enough land available for a septic system

to top

Are Aerobic Systems Right for My Community?

Aerobic treatment systems are not accepted in all areas. Regulations for onsite systems can vary from one local government to the next. A major reason that aerobic systems are not more widely used is concern about improper operation and maintenance by homeowners. Aerobic systems require regular maintenance, and abuse or neglect can easily lead to system failure.

In answer to these concerns, NSF *International* (formerly the National Sanitation Foundation) has tested aerobic units according to the requirements of ANSI/NSF Standard 40. NSF *International* is a nonprofit organization devoted to the protection of public health and the environment through the development of product standards, product evaluations, research, education, and training. The American National Standards Institute (ANSI) is the recognized accreditor in the U.S. for organizations that develop consumer standards and for those that provide independent product evaluations. NSF is accredited by ANSI for both of these areas of service.. Aerobic units that satisfy the requirements of ANSI/NSF Standard 40 may carry the NSF mark.

In addition to testing their units, NSF requires manufacturers to include the cost of the first two years of service in the price of purchase. During this initial service contract, each piece of equipment must be serviced a minimum of two times per year, and emergency service must be available to the homeowner. Manufacturers must also offer the homeowner the option of renewing the service contract after the two years.

In most cases, the service contract is carried out by the dealer selling the aerobic unit, who represents the manufacturer. Standard 40 details what type of service is to be performed and what records need to be kept. Both the manufacturers and their distributors are inspected annually by NSF to ensure continued compliance with the requirements.

Some state and local governments that allow aerobic treatment require that units carry the NSF approval. Your local health department will be familiar with the regulations and permit requirements for your area, as well as which onsite options are best for your particular property.

Aerobic Treatment: Pros and Cons

Advantages

- Can provide a higher level of treatment than a septic tank
- Helps to protect valuable water resources where septic systems are failing
- Provides an alternative for sites not suited for septic systems
- May extend the life of a drainfield
- May allow for a reduction in drainfield size

Disadvantages

- More expensive to operate than a septic system
- Requires electricity
- Includes mechanical parts that can break down
- Requires more frequent routine maintenance than a septic tank
- Subject to upsets under sudden heavy loads or when neglected
- May release more nitrates to groundwater than a septic system

to top

How Aerobic Treatment Works

Aerobic systems treat wastewater using natural processes that require oxygen. Bacteria that thrive in oxygen-rich environments work to break down and digest the wastewater inside the aerobic treatment unit. Like most onsite systems,

aerobic systems treat the wastewater in stages. Sometimes the wastewater receives pretreatment before it enters the aerobic unit. Treated wastewater leaving the unit requires additional treatment (passage through a soil absorption field) before being returned to the environment. Wastewater discharge from individual residential on-site disposal systems to Indiana waters is not permitted.

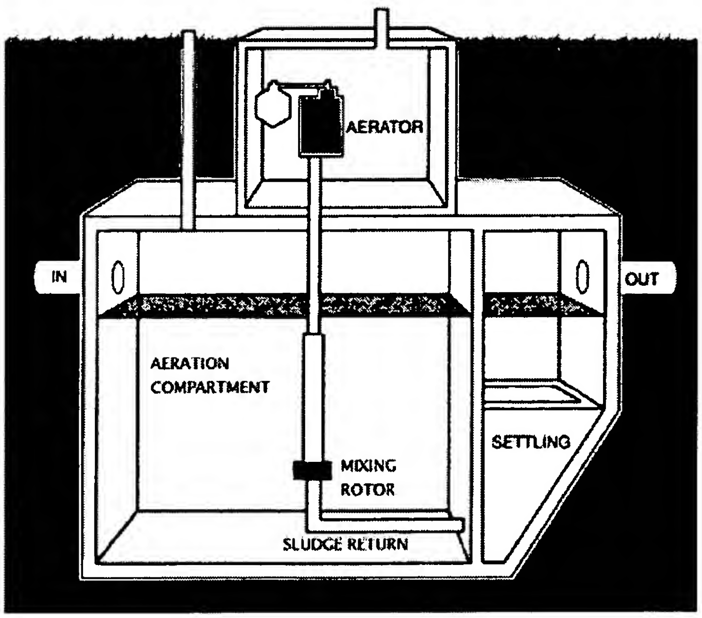
Such a variety of designs exist for home aerobic units and systems that it is impossible to describe a typical system. Instead, it is more practical to discuss how some common design features of aerobic systems work and the different stages of aerobic treatment.

Pretreatment

Some aerobic systems include a pretreatment step to reduce the amount of solids in the wastewater going into the aerobic unit. Solids include greases, oils, toilet paper, and other materials that are put down the drain or flushed into the system. Too much solid material can clog the unit and prevent effective treatment. Some pretreatment methods include a septic tank, a primary settling compartment in the treatment unit, or a trash trap.

Aerobic Treatment Units

The main function of the aerobic unit is to collect and treat household wastewater, which includes all water from toilets, bathtubs, showers, sinks, and laundry. Aerobic units themselves come in many sizes and shapes-rectangular, conical, and some shapes that defy classification.



Suspended Growth Units

The process most aerobic units use to treat wastewater is referred to as suspended growth. These units include a main compartment called an aeration chamber in which air is mixed with the wastewater. Since most home aerobic units are buried underground like septic tanks, the air must be forced into the aeration chamber by an air blower or a compressor.

The forced air mixes with wastewater in the aeration chamber, and the oxygen supports the growth of aerobic bacteria that digest the solids in the wastewater. This mixture of wastewater and oxygen is called the mixed liquor. The treatment occurring in the mixed liquor is referred to as suspended growth because the bacteria grow as they are suspended in the liquid unattached to any surface.

Unfortunately, the bacteria cannot digest all of the solids in the mixed liquor, and these solids eventually settle out as sludge. Many aerobic units include a secondary chamber called a settling chamber or clarifier where excess solids can settle. Other designs allow the sludge to accumulate at the bottom of the tank.

In aerobic units designed with a separate settling compartment, the sludge returns to the aeration chamber (either by gravity or by a pumping device). The sludge contains bacteria that also aid in the treatment process. Although, in theory, the aerobic treatment process should eventually be able to consume the sludge completely, in practice, the sludge does build up in most units and will need to be pumped out at least once a year so that solids don't clog the unit.

Attached Growth Units

An alternative design for aerobic treatment is the attached growth system. These units treat wastewater by taking a surface made of material that the bacteria can attach to, and then exposing that surface alternately to wastewater and air. This is done either by rotating the surface in and out of the wastewater or by dosing the wastewater onto the surface. Pretreatment is required. The air needed for the process is either naturally present or is supplied mechanically.

Attached growth systems, such as trickling filters and rotating disks, are less common than suspended growth systems, but have certain advantages. For example, there is no need for mixing, and solids are less likely to be washed out of the system during periods of heavy household water use

Flow Design

The way and the rate in which wastewater is received by and flows through the aerobic unit differs from design to design. Continuous flow designs simply allow the wastewater to flow through the unit at the same rate that it leaves the home. Other designs employ devices (such as pretreatment tanks, surge chambers, and baffles) to control the amount of the incoming flow. Batch process designs use pumps or siphons to control the amount of wastewater in the aeration tank and/or to discharge the treated wastewater in controlled amounts after a certain period of time.

Controlling the flow of wastewater helps to protect the treatment process. When too much wastewater is flushed into the system all at once, it can become overburdened and the quality of treatment can suffer. The disadvantages to mechanical flow control devices are that, like all mechanical components, they need maintenance and run the risk of malfunctioning.

Homeowners can help their system's performance by conserving water. Leaking faucets and running toilets should be repaired, and washing machines and dishwashers should be used only when full. Installing water saving devices in toilets, faucets, and showers can reduce water use by up to 50 percent. Also, homeowners should try to space out activities requiring heavy water use (like laundry) to avoid overloading their systems.

Final Treatment And Disposal

Although properly operated and maintained aerobic units are very effective, the wastewater leaving the units is not ready to be returned to the environment and must receive final treatment. Methods for final treatment include discharge to a soil absorption field and/or a sand filter. Soil absorption fields (or drainfields) are the most common method of final treatment. An aerobic unit can sometimes help to prolong the life of a drainfield. Your health department is familiar with local regulations and the treatment options that are best in your area and for your property.

The amount of dissolved oxygen contained in wastewater from an aerobic unit can help the growth of microorganisms that treat the wastewater in the soil, and can help prevent the pores in the soil from clogging. However, when aerobic units malfunction, they can release solids that can clog the drainfield, which may cancel out any potential benefits.

Sand filters are sometimes used to treat the wastewater from aerobic units. The wastewater is pumped evenly over several layers of sand and gravel, which are located either above or below ground. As with soil treatment systems, the purification process is aided by bacteria that occur naturally in the sand.

to top

Other Design Considerations

Controls and Alarms

Most aerobic units have controls that can be switched on and off by the homeowner in case of emergency. Aerobic units also are required to have alarms to alert the homeowner of malfunctions. Depending on the design of the system, controls and alarms can be located either inside or outside the home, and alarms can be visible, audible, or both.

Homeowners should make sure that controls and alarms are always protected from corrosion, and that the aerobic unit is turned back on if there is a power outage or if it is turned off temporarily.

Size

Aerobic units should be large enough to allow enough time for the solids to settle and for the wastewater to be treated. The size of most units range from 300 to 1,500 gallons per day, but local regulations often require that the unit be at least large enough to handle 500 gallons of wastewater per day.

The needed size of an aerobic unit is often estimated the same way the size of a septic tank is estimated, by the number of

bedrooms (not bathrooms) in the house. It is assumed that each person will use approximately 75 to 100 gallons of water per day, and that each bedroom can accommodate two people. When calculated this way, a three-bedroom house will require a unit with a capacity of 450 to 600 gallons per day.

Some health departments require that aerobic units be sized at least as large as a septic tank in case the aerobic unit malfunctions and oxygen doesn't mix with the wastewater. In such cases, the aerobic unit will work as a septic tank-which will, at least, provide partial treatment for the wastewater.

Temperature

Lower temperatures tend to slow down most biological processes, and higher temperatures tend to speed them up. The aerobic process itself creates heat, which, along with the heat from the electrical components, may help to keep the treatment process active. However, cold weather can have adverse effects on the performance of aerobic units.

In one study of aerobic units, there were problems when the temperature of the wastewater inside some of the units fell below 15 degrees Celsius (59 degrees Fahrenheit). Problems can sometimes be avoided by insulating around the units. Your health department should know whether aerobic systems are suitable for your area.

to top

Aerobic System Do's and Don'ts

Do's

- Do maintain the contract service arrangement offered by the manufacturer after the initial two-year period has expired (unless your community offers its own management program). It is extremely important that aerobic systems receive regular maintenance.
- Do keep your system accessible for inspections and pumping, yet protected from unauthorized entrance. If access to your system is locked, make sure that your service contractor has a key.
- Do call a service professional whenever you experience problems with your system, whenever the alarm is activated, or whenever there are any signs of system failure.
- Do keep detailed records about your aerobic system, including a map of where it is, and general information, such as model name, capacity, state license, date installed, contract service agreement, records of service visits, and maintenance performed.
- Do conserve water to avoid overloading the system. Be sure to repair any leaky faucets or toilets.
- Do divert other sources of water, like roof drains, house footing drains, and sump pumps away from the aerobic system.
- Do become familiar with how your own particular system operates, and the way it looks, sounds, and smells when it is working correctly. This way, you may be able to identify problems before they become serious and alert your service provider to anything unusual.
- Do be sure to ask your service provider questions about how to know if your unit is malfunctioning.

Don'ts

- Don't allow anyone to drive over or park on any part of the system.
- Don't make or allow unauthorized repairs or changes to your aerobic system without obtaining the required health department permits.
- Don't use your toilet as a trash can or poison your treatment system and the groundwater by pouring harmful chemicals down the drain. Harsh chemicals can kill the beneficial bacteria that treat your wastewater.
- Don't use a garbage disposal without checking with your local regulatory agency to make sure that your aerobic system can accommodate this additional waste.
- Don't attempt to clean or perform maintenance on any sealed aerobic unit components.

Do Not Flush...

coffee grounds	dental floss	disposable diapers	paints	pesticides
kitty litter	sanitary napkins	tampons	varnishes	photographic solutions
cigarette butts	condoms	gauze	thinners	
bandages	fat, grease, or oil	paper towels	waste oils	

These items can overtax or destroy the biological digestion taking place within your system.

Aerobic System Maintenance

It is important that mechanical components in aerobic systems receive regular inspection and maintenance. For example, air compressors sometimes need to be oiled, and vanes, filters, and seals may need to be replaced. Malfunctions are common during the first few months after installation. In most cases, homeowners do not have the expertise to inspect, repair, and maintain their own systems.

If your unit carries the NSF approval, it will include the first two years of service visits with the purchase price and an option to renew the service contract after two years. It is a good idea for homeowners to renew their service agreements after two years, or to find another service organization to take over the job. This may be a requirement of the permit.

In addition to routine maintenance, NSF requires service contractors to stock replacement parts for mechanical components and to be available for emergency servicing. Under the original two-year agreement, failed equipment is replaced at no additional cost to the homeowner.

The service contract may or may not cover such problems as damage from power failures, breaking or crushing of pipes leading to and from the system, flooding, fires, homeowner misuse, and other catastrophes beyond the control of the manufacturer.

Service visits will most likely be carried out by the dealer or another independent service organization that has an agreement with the manufacturer. In other cases, health departments will have maintenance management programs, such as sanitary districts, for aerobic systems and other onsite systems in their area. In general, we recommend a professional inspection and maintenance every three months.

Warning Signs of Aerobic System Problems

- Alarms or lights going off
- Any changes in the system's normal operating sound
- Any changes in the normal color of the wastewater in the aeration on chamber (for example if the color is greyish brown rather than chocolate brown this can sometimes indicate problems)
- Excessive solids, foam, or scum in the unit
- Plumbing backups
- Sewage odors in the house or yard

What to Expect at a Typical Service Visit

The first service visit should be scheduled immediately after the system is installed to make sure that everything is working correctly. The service contractor may also arrange a meeting with the homeowner to go over issues, such as proper operation, what to do in case of emergency, etc… For seasonal properties, homeowners will need to know how to shut the system down in the off season and start it again when needed. After the first visit, the maintenance service contract is issued to the homeowner.

The maintenance contract may include at least two service visits per year for the next two years. The number of visits and service performed will differ from unit to unit and location to location depending on manufacturers' recommendations and local regulations.

During a typical visit, the service provider will remove the unit's cover and check its general appearance. He or she will check pipes and the inside of the aeration chamber, and will note the appearance of the wastewater inside the unit and its color and odor. Samples may be taken of the mixed liquor from the aeration chamber, as well as the final treated wastewater. The operator will also check to see that all mechanical parts, alarms, and controls are in working order, and that solids are pumped from the system if needed. The soil absorption field, sand filter, or other method of final treatment may also be inspected by the service provider.

Record Keeping

It is a good idea for the homeowner or the service provider to keep detailed records about the system and service visits. NSF approved units are required to include a user's manual that describes such things as the manufacturer's recommendations for the unit, the system design, how to operate and maintain it, as well as how to tell if it is working properly. The state license, the date the system was installed, the type of disinfection, and any modifications to the system should also be recorded.

Other important information to keep on hand includes where to contact the owner if nobody is home, where to find a key to the system, and the schedule for service visits. Homeowners should keep their own copies of all records and permits.

to top

How much does aerobic treatment cost?

The cost of aerobic treatment varies depending on factors, such as design, size, location, and operation and maintenance requirements. Some of the factors affecting the cost of aerobic treatment are as follows:

- unit price
- cost of unit installation and electricians' fees
- cost of construction of the drainfield or cost of other method of additional treatment if required
- cost of electricity (per year)
- maintenance service contract fee (per year)
- cost of disinfection (if applicable)

The price of some of these factors, such as unit price, may be adversely affected by the lack of demand for aerobic systems in certain areas. Installation costs may be higher for aerobic units than for septic tanks because of the electrical work required. All of these factors need to be carefully considered when determining the cost-effectiveness of aerobic treatment versus other treatment methods. Your local health official can help you evaluate your options.

For more Information:

Health Departments: If you would like more information about aerobic units or are interested in utilizing one, contact your local health department or the Indiana State Department of Health at (317) 233-7177 for assistance. (Local health department phone numbers are usually listed in the government section of local phone directories.)

National Small Flows Clearinghouse (NSFC): The National Small Flows Clearinghouse (NSFC), which specializes in on-site technology, operation, maintenance, regulations, management, finance, and education, has a variety of free and low-cost products available. NSFC can be reached at (800) 624-8301.

Extension Service: Extension service offices can provide assistance and information about many of the wastewater treatment issues discussed. To locate the extension office in your area, call Purdue University at (888) 398-4636, the U.S. Department of Agriculture at (202) 720-3377 or NSFC.

NSF International (formerly the National Sanitation Foundation): NSF *International is* a private, nonprofit organization devoted to research, education, service, and training that tests and publishes standards for products relating to public health and the environment. To order the ANSI/NSF Standard 40, see the listing at the bottom of this page. For more information, you may contact NSF at (800) NSF-MARK.

to top

To Purdue Wastewater Articles On-Line

Pipeline, Winter, 1996. Vol. 7, No. 1.

*Catherine Taylor and Joseph Yahner, Agronomy (765) 494-4773, Don Jones, Agricultural Engineering (765) 494-1167, Purdue University and Alan Dunn, Indiana State Department of Health (317) 233-7177. The On-Site Project is in cooperation with the Indiana State Department of Health.

Aerobic Residential Onsite Sewage Systems: An Evaluation of Treated-Effluent Quality

Meliss Maxfield, R.E.H.S./R.S., M.P.H
William E. Daniell, M.D., M.P.H.
Charles D. Treser, M.P.H.
Jim VanDerslice, Ph.D.

Abstract

This retrospective cohort study used existing data to evaluate the quality of effluent from three of the most common types of onsite residential aerobic treatment sewage systems (Multi-Flo™, Norweco™, and Whitewater™) installed in Kitsap County, Washington. Five-day biochemical oxygen demand (BOD_5), total suspended solids (TSS), and fecal-coliform-bacteria parameters were used to determine performance. Although most (77 percent) of the systems were less than one year old at the time of sampling, over a third failed to meet NSF certification standards for BOD_5 and TSS in effluent (<30 milligrams per liter [mg/L]). Over two-thirds of systems failed to meet Washington State Board of Health Treatment Standard 2 criteria for BOD_5 and TSS (<10 mg/L). Furthermore, an average of 59 percent of the systems failed to meet state standards for fecal coliform (<800 fecal coliform bacteria per 100 milliliters).

Introduction

Aerobic treatment unit (ATU) systems are becoming more prevalent in the state of Washington because the better-drained lots have been developed, leaving only lots with more poorly drained soils available for development. In addition, amendments made in 1995 to the State Board of Health On-Site Sewage Regulations, Chapter 246-272 WAC, restrict the installation of standard gravity onsite sewage systems in the state to lots that have a minimum of 2 feet of soil available above the water table or an impervious layer (e.g., clay or hardpan). Much of the undeveloped area of Kitsap County has either a high water table or a clay or hardpan soil that prohibits installation of conventional gravity onsite sewage systems, leaving alternative onsite systems as the only choice. The most common reasons aerobic systems are used are that there is not enough land area to accommodate the soil absorption, that soil conditions are not appropriate, or that the water table is too high to allow adequate treatment of the wastewater in the drainfield before the water is released to the groundwater. Another site-related concern is the existence of lots close to surface water. One o: the most common reasons that aerobi wastewater treatment units are chosen is t replace failing septic systems.

In Chapter 246-272 WAC, the Washingto State of Board of Health On-site Sewag Regulations allow placement of ATUs withi 100 feet or less of domestic drinking-wate supplies (Washington State Board of Healtł 1995) because ATUs can treat sewage efflu ent to a higher standard than a convention gravity onsite sewage system. In Sectio 15501 of 246-272 WAC, the regulation require that the local health officer provid operation and maintenance information t homeowners of onsite sewage systems, an initiate periodic monitoring of each onsi sewage system. This mandate, however, unfunded (i.e., though it is a state regulatio no funding mechanism is provided to car out the requirement). Many local healt jurisdictions only provide information material and do not require homeowners t submit results from effluent testing.

Methods

The study sample consisted of 184 residenc with onsite ATUs in Kitsap Coun Washington, with at least one effluent samp reported to the Bremerton-Kitsap Coun Health District during 1995 through 1999. total of 781 effluent sample results were repo ed from these onsite ATU sewage systems. T three brand-name ATUs of interest were: Mul Flo™, Norweco™, and Whitewater™.

TABLE 1

ATU Type and Effluent Characterization

Non-chlorinated Samples	Log BOD_5	Log TSS	Log FC
[illegible]	[illegible]	[illegible]	[illegible]
Multi-Flo	0.8 ± 0.7*	0.9 ± 0.7	2.1 ± 1.1
Whitewater	1.4 ± .5	1.3 ± 0.6	3.2 ± 1.3
Norweco	1.5 ± .4	1.3 ± 0.6	2.8 ± 0.7
Significance**	$p < .001$	$p < .001$	$p < .001$
[illegible]	[illegible]	[illegible]	[illegible]
Winter	1.0 ± 0.7*	1.2 ± 0.7	2.6 ± 1.2
Spring	1.5 ± 0.6	1.2 ± 0.7	2.7 ± 1.3
Summer	1.3 ± 0.6	1.2 ± 0.7	2.9 ± 1.3
Fall	1.3 ± 0.6	1.4 ± 0.6	3.4 ± 1.1
Significance**	$p < .001$	$p < .26$	$p < .04$
[illegible]	[illegible]	[illegible]	[illegible]
MTuW	1.4 ± 0.7*	1.3 ± 0.8	3.2 ± 1.6
ThF	1.2 ± 0.6	1.2 ± 0.6	2.7 ± 0.9
Significance**	$p < .02$	$p < .09$	$p < .01$
[illegible]	[illegible]	[illegible]	[illegible]
Morning	1.1 ± 0.6*	1.2 ± 0.7	2.5 ± 1.0
Afternoon	0.8 ± 0.8	0.8 ± 0.8	2.1 ± 0.7
Significance**	$p < .12$	$p < .03$	$p < .20$

*Mean and (±) standard deviation.
**One-way ANOVA.

The data for this study came from annual operation and maintenance reports that were submitted to the health district. These data included name and address of property owner, type of ATU, tax parcel number, installation date, and results of five-day biochemical oxygen demand (BOD_5), total suspended solids (TSS), and fecal-coliform testing.

The underlying population comprises all the residences with an ATU in Kitsap County, including those for which no effluent test results were reported to the Bremerton-Kitsap County Health District. The extent of non-reporting is not known, and the size of the population could not otherwise be determined.

Analysis of Data

The analysis of data included descriptive evaluation of the effluent measurements and independent variables (i.e., type of ATU, as well as season, day of week, and time of day of sample collection). A comparison of effluent measurements for the ATUs followed, using group means, *t*-tests, and one-way analysis of variance (ANOVA). The authors used analysis of covariance to compare ATUs while controlling for possible confounding factors associated with the independent variables. Finally the sample results were compared with both state and national standards to assess compliance with these requirements.

Results

Almost half (45 percent) of the ATUs in the study sample were Whitewater units. Multi-Flo units were the next most common (31 percent), followed by Norweco (22 percent). Most (77 percent) of the ATUs were no more than 12 months old at the time of sampling. The Multi-Flo and Whitewater ATUs were about twice as likely (42 percent and 31 percent, respectively) to be very new (i.e., newer than six months at first sampling) as were the Norweco ATUs (18 percent).

The installation dates were not documented for all sites; dates were readily available, however, for 102 (83.7 percent) of the 184 sites. The age of each system was calculated as the time between the first sampling event and the installation date, if an installation date was known.

Effluent Samples

Several state-certified laboratories were involved in analysis of the effluent samples. The samples were analyzed in accordance with methods described in *Standard Methods for the Examination of Water and Wastewater Analysis* (Lenore & Greenberg, 1998).

A total of 781 non-chlorinated effluent samples were collected, of which 38 percent were analyzed for both BOD_5 and TSS, and 24 percent were analyzed for fecal coliforms (FC). For all three effluent parameters, some results were high; however, county laboratory personnel indicated that these results were within the range of plausibility. Because the effluent data were skewed toward higher values, the data were transformed logarithmically to yield a more nearly symmetric or normal distribution when necessary for data analysis.

Relationship of BOD_5, TSS, and Log FC

Bivariate associations were examined with the Pearson correlation coefficient to see if there was any linear association among the effluent parameters. A high degree of correlation between log BOD_5 and log TSS was found ($r = .8$, $p < .001$). Each of these parameters showed a weaker but still statistically significant correlation with log FC (for each pair, $r = .5$, $p < .001$).

Differences in Effluent Quality, ATU Type, and Sample Timing

On average, effluent from Multi-Flo units was of better quality than that from units of the other two types (Table 1). One-way ANOVA found significant differences among the three ATU types for each of the three effluent parameters (for each parameter, $p < .001$). Some of the effluent parameters also showed significant differences depending on when the samples were collected. The values for log BOD_5 and log FC differed significantly by the season, with log BOD_5 tending to be lowest in samples collected during the winter and log FC tending to be highest in fall samples. Values for log BOD_5 and log FC also tended to be lower in samples collected in the first half of the week. No pattern relative

to season or day of the week was evident for log TSS values. In the small number of samples for which time of day was noted, however, log TSS values generally were lower for samples collected in the early afternoon than for samples collected in the morning.

Multivariate Analysis

The authors used analysis of covariance to evaluate the differences among the ATUs for each of the three effluent parameters while controlling for possible differences arising from when samples were collected. The analysis did not include the time of day, because this information was available for only a fraction of the samples. The *B* values in Table 2 represent the difference between the average value for a specified category (e.g., Norweco ATU) and the average value for the corresponding reference category (i.e., Whitewater ATU) on a logarithmic scale, with the other variables shown in the table being controlled for. The reference categories were chosen arbitrarily and were assigned a relative value of 0 (because a reference category does not differ from itself). Table 2 also shows 95 percent confidence intervals (95 percent CIs) in parentheses for each value; the difference between a *B* value and its reference value is statistically significant (i.e., $p < .05$) if the 95 percent CI does not include zero.

The effluent samples were collected between spring 1995 and fall 1999. Over a quarter (28 percent) of the samples were taken during the months of December and January, and samples were taken next most frequently in June and July (22 percent). The majority of the effluent samples were collected during four time periods: summer 1997 (13 percent), winter 1998 (15 percent), fall 1998 (10 percent), and winter 1999 (11 percent). Overall, more than one-third (37 percent) of the samples were collected during the winter season, and less than one-quarter (17 percent) were collected in the spring. The most common sampling day was Thursday (60 percent), followed by Tuesday (21 percent). Very few samples were collected on Saturday or Sunday (0.6 percent and 0.9 percent, respectively). Sample collection times were available for only 85 samples; of these, 81 percent were taken in the morning.

The multivariate analysis delineated in Table 2 found that the Multi-Flo ATU had significantly lower log BOD_5, log TSS, and log FC values than did the Whitewater ATU, while controlling for possible differences arising from sample collection times. The quality of effluent

TABLE 2

Differences in ATU Effluent Quality, Adjusted for When Samples Were Collected

Main Effects	Log BOD_5		Log TSS		Log FC	
	B	95% CI	B	95% CI	B	95% CI
ATU						
Norweco	.19	(–0.00, 0.38)	–.03	(–0.19, 0.25)	–.29	(–0.81, 0.23)
Multi-Flo	–.47	(–0.65, –0.30)	–.37	(–0.57, –0.18)	–1.0	(–1.5, –0.60)
Whitewater	0		0		0	
Season						
Winter	–.23	(–0.44, –0.002)	–.07	(–0.12, 0.31)	.36	(–0.24, 0.95)
Summer	–.14	(–0.36, 0.08)	–.01	(–0.26, 0.24)	.75	(0.13, 1.4)
Fall	–.13	(–0.35, 0.01)	.16	(–0.09, 0.42)	.74	(0.01, 1.4)
Spring	0		0		0	
Day of Week						
M–W	.11	(–0.06, 0.27)	.01	(–0.09, 0.28)	.44	(0.06, 0.82)
Th–F	0		0		0	

0 = reference category.
95% CI = 95% confidence interval.

TABLE 3

Seasonal Variation in ATU Performance

Interaction	Log BOD_5		Log TSS		Log FC	
	B	95% CI	B	95% CI	B	95% CI
Multi-Flo						
Spring	.42	(0.21, 0.64)	.06	(–0.18, 0.29)	.10	(–0.50, 0.69)
Summer	.24	(0.05, 0.43)	.02	(–0.18, 0.23)	.28	(–0.17, 0.73)
Fall	.32	(0.11, 0.52)	.21	(–0.01, 0.43)	.74	(0.24, 1.3)
Winter	0		0		0	
Norweco						
Spring	.47	(0.06, 0.88)	–.71	(–1.2, –0.20)	–1.8	(–2.7, –0.88)
Summer	–.07	(–0.37, 0.23)	–.40	(–0.78, –0.03)	–.49	(–1.1, 0.10)
Fall	.23	(–0.08, 0.54)	.02	(–0.37, 0.40)	–.19	(–0.81, 0.43)
Winter	0		0		0	
Whitewater						
Spring	.12	(–0.15, 0.39)	.03	(–0.29, 0.35)	.01	(–0.77, 0.78)
Summer	–.02	(–0.27, 0.24)	–.09	(–0.40, 0.22)	.24	(–0.47, 0.95)
Fall	–.05	(–0.30, 0.21)	–.03	(–0.34, 0.27)	.39	(–0.28, 1.1)
Winter	0		0		0	

0 = reference category.
95% CI = 95% confidence interval.

FIGURE 1

Five-Day BOD by System Type and Season

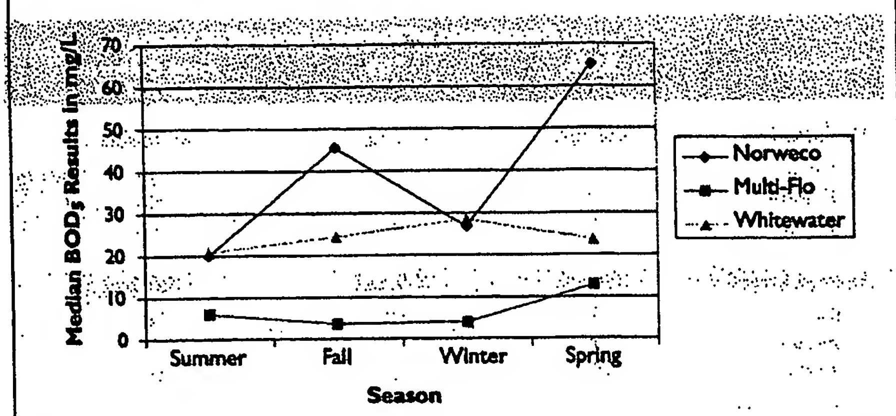


FIGURE 2

Total Suspended Solids by System Type and Season

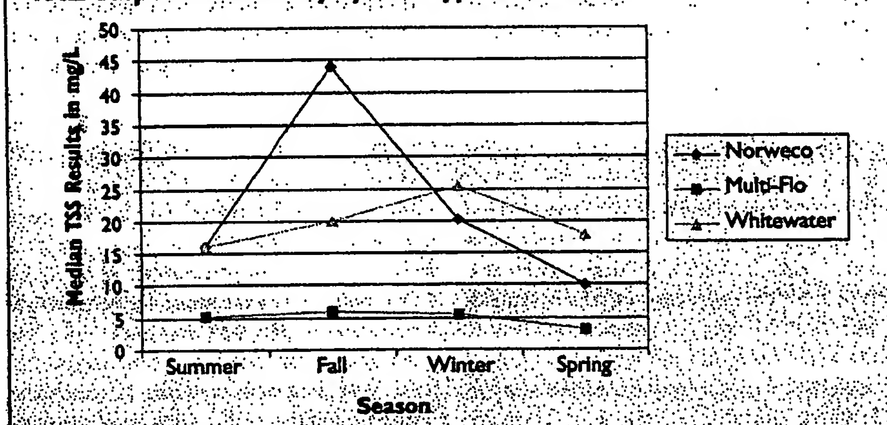
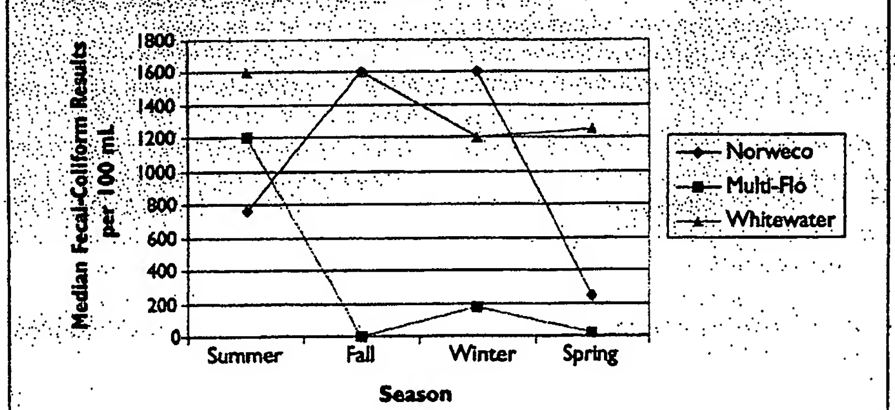


FIGURE 3

Fecal Coliform by System Type and Season



from the Norweco and Whitewater ATUs did not, however, significantly differ. Regardless of ATU type, the log BOD_5 values generally were lower in samples collected during summer, fall, and winter months than in samples collected in the spring. These differences, however, were statistically significant only for winter samples compared with spring samples. Conversely, the log FC counts generally were higher during the nonspring months, although the difference was statistically significant only for samples collected in summer and fall.

The seasonal variation in effluent quality was not uniform across the different types of ATUs (Table 3). Winter was chosen as the reference season for the model examining seasonal variation because samples collected in the winter tended to show the least variation by ATU and the three sewage parameters. When only the records for samples collected during winter were considered, no significant difference was found between Whitewater ATUs in the regression models for log BOD_5, log TSS, and log FC. The Multi-Flo ATU, however, did have log BOD_5 values that differ significantly from those of the other two types.

To further investigate how much difference there was among the ATUs, Multi-Flo ATUs were chosen as the reference for the models examining ATU variance across the different seasons because samples collected from the Multi-Flo ATUs tended to show the least variation by season for the three sewage parameters (Figure 1, Figure 2, Figure 3). When only the records for samples collected from Multi-Flo ATUs were considered, the regression models for spring, summer, and fall found no significant difference among the seasons. Samples from the Whitewater and Norweco ATUs did, however, significantly differ from Multi-Flo samples for the season winter.

Comparison with Standards

Overall, the performance of the ATUs in this study failed to consistently meet either state or national effluent standards (Table 4).

Discussion

This population-based study of residential onsite ATUs in one Pacific Northwest county found that over a third of the ATUs failed to meet NSF certification standards for BOD_5 and TSS in effluent (<30 mg/L). In addition, over two-thirds of the ATUs failed to meet the Washington State Board of Health Treatment Standard 2 criteria for BOD_5 and TSS (<10 mg/L), and a majority of the sys-

tems (59 percent) failed to meet state standards for fecal coliform (<800 fecal coliforms per 100 mL). The high prevalence of substandard performance is particularly remarkable when it is recognized that most (77 percent) of the systems were not even one year old at the time of sampling.

The results of this study generally agree with those of previous studies and demonstrate that many systems actually in use do not produce an effluent that meets local or state standards. This study found only 36 percent of the systems tested produced an effluent that met the BOD_5 Treatment Standard 2 of less than 10 mg/L. While many studies also found generally high BOD_5 effluent levels (Brewer, Lucas, & Prascak, 1978; Hutzler, Fancy, & Waldorf, 1978; Kellam, Hagedorn, & Reneau, 1993), some studies have found that the systems perform well (Island County Health Department, 1999; Mancl & Vollmer, 2001). Similarly, TSS levels were high in many cases, with only 39 percent meeting the Treatment Standard 2 of less than 10 mg/L. Again, this result is consistent with those of other studies, which also found generally high TSS levels in effluent (Brewer, Lucas, & Prascak, 1978; Hutzler, Fancy, & Waldorf, 1978; Kellam, Hagedorn, & Reneau, 1993; Mancl & Vollmer, 2001), but it is in contrast with the findings of one study that found only 8 percent BOD_5 and 15 percent of TSS sampling results not in compliance with Treatment Standard 2 requirements (Island County Health Department, 1999). The systems tested in this study may have performed worse because of influent waste strength or hydraulic overloading by homeowners. This deficiency in performance is particularly remarkable given that the ATUs were examined early in their life span.

This study also found that only 38 percent of the tested systems produced an effluent that met the Treatment Standard 2 requirement of less than 800 fecal coliforms per 100 mL. Three other studies found that 35 percent (Kellam, Hagedorn, & Reneau, 1993), 36 percent (Mancl & Vollmer, 2001), and 55 percent (Island County Health Department, 1999) of the fecal-coliform results met their respective state requirements.

Overall, effluent quality varied significantly by type of system. Multi-Flo units generally had better effluent quality for BOD_5, TSS, and fecal coliform than did units of the other two types, while the Whitewater and Norweco units generally were comparable. By contrast, the only other study that evaluated the same brands of ATUs found a statistical difference in BOD_5 levels between Whitewater and Multi-Flo units and no statistical significance difference in TSS between the two types of unit (Island County Health Department, 1999).

There were substantial seasonal variations in effluent quality, especially for BOD_5. Generally, higher levels of BOD_5 were found in spring, and lower fecal-coliform counts were found in winter. Effluent quality also varied by day of week on which samples were analyzed; analysis that occurred later in the week was significant for BOD_5 and fecal coliforms, with the majority of the samples analyzed either on a Tuesday or Thursday. Performance differed somewhat by season, with winter having the best effluent quality and fall having the worst. The only other study that could be found that evaluated the effect of seasonal variation found no overall trends (Kellam, Hagedorn, & Reneau, 1993).

Grab samples have more limited accuracy, characterizing ATU performance at one point in time, than do samples collected over a longer period of time (e.g., 24 hours). The accuracy of grab samples, however, is sufficiently acceptable for the method to be used routinely by regulatory agencies to monitor and evaluate ATU performance in the field. This study used the data available in the existing database of a regulatory agency, allowing the authors to evaluate the performance of a large number of ATUs of several types in a large geographic region. Future studies should consider using longer sample collection periods.

Although ATUs are certified through NSF according to a rigorous testing protocol, the results obtained during such testing do not appear to be reflective of in-the-field results found by this and other studies. Currently no active programs require periodic monitoring of effluent quality from ATUs in the state. The findings of this study indicate that performance monitoring should be ongoing to evaluate not only the initial performance, typically called the design life (Jantrania, 1998), bu the long-term performance of the units One would have expected to see better result from newer ATUs than from older units, bu that was not the case here. If one accepts tha the state treatment standard is reasonable then the findings of this study bring into ques tion both the reliability of ATUs for routin residential use and the reduction of the hori zontal separation requirement to within 10 feet of drinking-water supplies. Reduction c regulatory horizontal separation criteria base on treatment of effluent is not advisable unt effluent standards are enforceable.

The use of ATUs will continue as the avai ability of better-drained lots diminishe leaving poorly drained soils for develo ment. This study could not evaluate ma factors that influence effluent quality; ho ever, it is significant that effluent from AT analyzed in this research did not meet sta or national requirements more than 60 pe cent of the time and that most of the syste were no more than 12 months old at the ti of sampling.

As ATUs become more prominent in t state of Washington, efforts are needed

TABLE 4

Performance of ATUs Compared with State and National Standards

Standard	Percentage of Samples Exceeding Limits: BOD_5	TSS	Fecal Coliforms per 100 mL
NSF Standard	≥30 mg/L	≥30 mg/L	No standard
Multi-Flo	12%	12%	N/A
Whitewater	36%	34%	N/A
Norweco	34%	28%	N/A
Treatment Standard 2	≥10 mg/L	≥10 mg/L	≥800 fecal
Multi-Flo	28%	34%	35%
Whitewater	74%	71%	74%
Norweco	89%	75%	69%

N/A = not applicable.

improve their performance. The authors recommend that the following measures be considered:

- more in-the-field evaluations of influent waste strength and how this factor affects the performance of the ATUs,
- improvement of homeowners' knowledge about their systems,
- operation and maintenance agreements that would require periodic effluent sampling and testing (as well as allow maintenance and operating personnel to troubleshoot performance problems), and
- more frequent (i.e., more frequent than semiannual) operation and maintenance inspections to minimize malfunctions and assist in homeowner education.

Corresponding Author: Meliss Maxfield, Water Quality Manager, Division of Drinking Water, Washington State Department of Health, 7171 Cleanwater Lane, Building 3, Olympia, WA 98504. E-mail: meliss.maxfield@doh.wa.gov.

REFERENCES

Brewer, W.S., Lucas, J., & Prascak, G. (1978). An evaluation of the performance of household aerobic sewage treatment units. *Journal of Environmental Health, 41*(2), 82-85.

Hutzler, N.J., Fancy, J., & Waldorf, L.E. (1978). Performance of aerobic treatment units. In *Proceedings of the 2nd National Home Sewage Treatment Symposium* (pp. 149-163). St. Joseph, MI: American Society of Agricultural Engineers.

Island County Health Department. (1999). Wastewater sampling assessment. Island County Special On-Site Demonstration Grant Program. Coupeville, WA: Author.

Jantrania, A. (Virginia Department of Health, Division of On-site Sewage and Water Services.) (1998). Monitoring protocol for on-site systems. http://plymouth.ces.state.nc.us/septic/98jantra3.html (14 Sept. 2000).

Kellam, J., Boardman, G., Hagedorn, C., & Reneau, R. (1993). *Evaluation of the performance of five aerated package treatment systems* (Bulletin 178). Blacksburg, VA: Virginia Water Resources Research Center, Virginia Polytechnic Institute and State University.

Lenore, C., Eaton, A., & Greenberg, A. (1998). *Standard methods for the examination of water and wastewater* (20th ed.). Washington, DC: American Public Health Association.

Mandl, K., & Vollmer, M. (2001). Management of individual mechanical sewage treatment systems: How much is needed? *Journal of Environmental Health, 63*(9), 22-25.

Washington State Board of Health. (1995). Chapter 246-272 WAC: On-site sewage systems. In *Rules and Regulations of the State Board of Health* (pp. 11-13). Olympia, WA: Author.